









CONSTRUCTABILITY IMPROVEMENT: MAKING  
EFFECTIVE USE OF CONSTRUCTION  
LESSONS LEARNED

by

Robert Henry Morro



Thesis submitted to the Faculty of the Graduate School  
of The University of Maryland in partial fulfillment  
of the requirements for the degree of  
Master of Science  
1991

Advisory Committee:

Assistant Professor Nabil Kartam, Chairman/Advisor  
Professor Donald Vannoy  
Professor William Maloney











## ABSTRACT

Title of Thesis: Constructability Improvement:  
Making Effective Use of Construction  
Lessons Learned

Robert Henry Morro, Master of Science, 1991

Thesis Directed by: Dr. Nabil Kartam  
Assistant Professor  
Civil Engineering Department

Expert knowledge and lessons-learned in the construction phase of a project are not being effectively fed back to the design and construction phases of subsequent projects. The advancement of construction since ancient times has been predicated on the communication of lessons-learned. Anecdotal story telling has evolved into case studies and formal systems for the classification and dissemination of lessons-learned. While past efforts have focused on the design phase, opportunities for collection and dissemination exist in all phases of the facility life-cycle. Constructability, the early integration of construction knowledge into all phases of a project, can be improved by effectively utilizing lessons-learned. Traditional methods of collecting and disseminating construction lessons-learned have enjoyed limited success due to the unmanageable format, the lack of a meaningful classification system, and difficulty integrating the new system into existing operations and procedures. Current

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hardware and software environments provide powerful tools for constructors to document and communicate lessons from the field more effectively. This thesis analyzes existing lessons-learned systems, identifies the challenges to effective feedback systems, and proposes a model of a knowledge based information system for construction. Potential benefits of an effective knowledge based feedback system include more efficient construction, higher quality projects, and safe, on schedule completion, for the least cost.



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DEDICATION

To my bella moglie, Anita.





## ACKNOWLEDGEMENT

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## CHAPTER I - INTRODUCTION

It has been said that the only thing we learn from our mistakes, is that we don't learn from our mistakes.

The inaugural article of the ASCE Journal of Performance of Constructed Facilities [Carper, 1987], highlights the importance of learning from the past:

The concept of learning from failures is fundamental to the practice of engineering. . . In the past, builders based their designs on observations of performance of earlier construction. Failures usually led to a better understanding of physical behavior and to a corresponding improvement in design. Communication among designers about lessons learned from failure has always been an important component in the advancement of the engineering professions.

During the construction of any facility, knowledge is gained and lessons are learned. Over time, those involved in construction processes have the opportunity to accumulate a plethora of knowledge, some of which was learned at great human or financial cost. Benefits in cost, quality, time and safety could be realized on future projects, if this wealth of constructability knowledge could be harnessed effectively.

The Constructability Task Force of the Construction Industry Institute (CII) sponsored a series of studies which advocate construction expert input to the conceptual planning [Tatum 1987], and engineering and procurement phases [O'Conner et al. 1987], as well as field operations [O'Conner et al. 1988], as the key to more efficient construction and



achievement of overall project objectives. While admitting that cost savings are difficult to quantify, the Business Roundtable estimates that constructability improvements saved 20 times the cost of the program ["More Construction" 1983]. Tatum expounds on the difficulties of quantification and enumerates some intangible benefits: team building, improved coordination, greater construction planning, and adoption of a project viewpoint by all team members [Tatum 1987].

Generally, lessons-learned in the construction phase of a project are not effectively being fed back to the design and construction phases of other projects. O'Conner and Davis conclude that **constructors** need to improve documentation of lessons-learned related to field constructability and to communicate them more effectively [O'Conner et al. 1988]. CII advocates a corporate lessons-learned database as a key element in any constructability program ["Guidelines" 1987]. Traditional methods of gathering and using lessons-learned have enjoyed limited success due to the unmanageable format, the lack of a meaningful classification system and the difficulty of integrating new systems into existing operations and procedures.

Knowledge based expert systems (KBES) provide a means of representing and reasoning with heuristics, or rules of thumb, employed by experts. Linking a database, a KBES, and hypertext capability facilitates rapid retrieval of information as well as the ability to reason within the knowledge base using if-





then rules. If the experience and lessons-learned at the construction site could be captured and incorporated in a dynamic, interactive, knowledge based information system and utilized in the design and construction of future facilities, great benefits could be realized. These benefits include more efficient construction and improved cost, quality and safety.

This research focuses on CONSTRUCTION. The goal is to develop a model of a practical tool with which to compile and benefit from the accumulated corporate knowledge of a medium or large size construction firm. The unit of knowledge is termed a lesson learned, and covers a broad spectrum of information from horse sense to technically sophisticated construction methods. We begin by exploring feedback opportunities in the project life-cycle, and analyzing related efforts to classify and utilize lessons-learned in engineering and construction. Challenges to effective feedback systems are then identified. Based on the analysis of existing systems, and consultation with construction industry experts, we develop a classification system for construction knowledge. Finally, we examine knowledge acquisition, knowledge engineering and implementation issues critical to the success of such a system.



## CHAPTER II

### FEEDBACK IN PROJECT LIFE-CYCLES

Lessons-learned from constructed facilities may have their genesis in any phase of a project's life-cycle. Similarly, these lessons may be applicable in one or more phases of the project life-cycle. The various sources and uses of engineering/construction knowledge are depicted in Figure 1. Three feedback loops from the construction project life-cycle will be examined in detail.

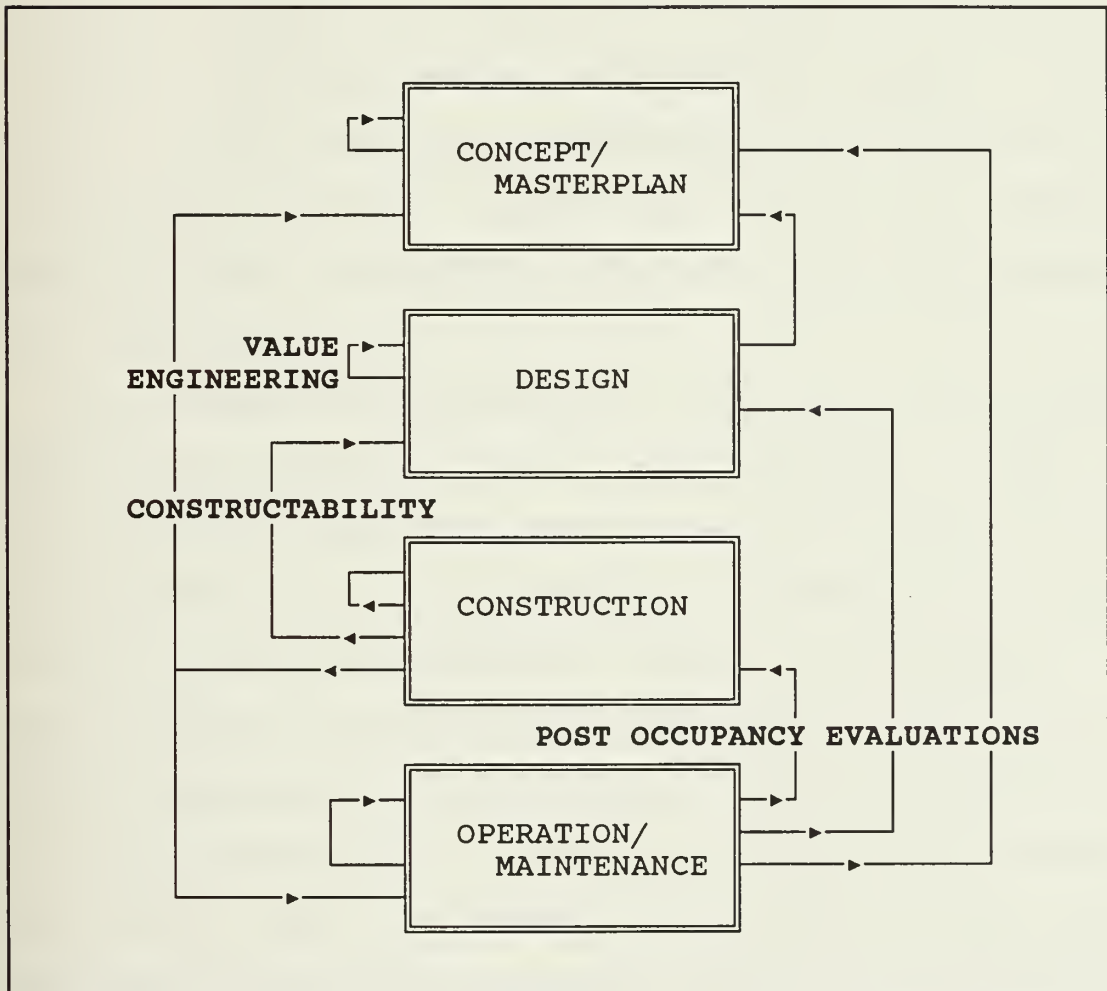
#### Value Engineering

Some feedback loops, for example, Value Engineering (VE), have become formalized in the construction industry. Value Engineering is traditionally viewed as an intentional reexamination of existing designs or hardware by the construction contractor, usually on an incentive basis [Kavanagh 1978]. Value Engineering, like constructability, focuses on life-cycle cost. VE is a feedback loop generally confined to the design phase.

Obviously, the earlier a value engineering study is conducted, the greater the potential to influence that project. VE studies that occur late in the design phase, or after design is complete, are limited. For example, the suggestion of an alternate structural system after the design



is complete, would most likely be rejected because it would entail substantial redesign and considerable loss of time. This illustrates the importance of feedback occurring, or lessons being available, as early in the process as possible. The concept of greater potential benefit from early feedback is a key element of constructability, and will be explored in the following section.



**FIGURE 1. Feedback Channels in Facility Life-Cycles**





## Constructability

Constructability provides yet another feedback mechanism in the life-cycle of a facility. But what exactly is constructability?

The Construction Industry Institute shuns the notion that constructability is merely a review of a completed design by construction experts. Rather, it espouses the basic constructability premise that integration of construction knowledge and expertise into **early** planning, design, and in fact, all phases of a project is beneficial. It also recognizes the need to bridge the traditional gap between engineering and construction **early** in the project if full benefit is to be achieved ["Guidelines" 1987]. CII has also commissioned various studies on ways to improve constructability [Tatum 1987, O'Conner et al. 1987, O'Conner et al. 1988].

The Construction Management Committee of the ASCE Construction Division echoes the sentiment that "a constructability program is not just reviewing the plans and specifications after the design is finished and making comments" ["Constructability" 1991]. It defines a constructability program as "the application of a disciplined, systematic optimization of the construction-related aspects of a project during the planning, design, procurement, construction, test, and start-up phases by knowledgeable, experienced, construction personnel who are part of a project



team" ["Constructability" 1991]. CII further recognizes that constructability is not a natural process, rather it demands a conscious, continued effort.

Constructability encompasses all feedback loops that emanate from the construction phase. The input of construction expertise is desirable in all phases of the facility life-cycle, and it is depicted accordingly in Figure 1. The focus of this research is the feedback loop that begins and ends in the construction phase.

### **Post Occupancy Evaluations**

Post Occupancy Evaluations (POEs) represent another formal feedback loop in engineering/construction. The evaluations occur during the operational and maintenance phase of the life-cycle, but can be applied in virtually any phase. Many owners of a large number of facilities employ POEs to assess the effectiveness of their design and construction programs. The Army, Navy and the General Services Administration all have active POE systems [Plockmeyer, 1988].

Comments made in a POE often pertain to the maintainability of the facility: provide adequate space in mechanical rooms to pull shafts from air handling units. Other comments relate to the durability and functionality of the constructed facility: quartz wall coverings are tough enough to withstand typical (ab)use in barracks settings, but light colors should be avoided since they show scuff marks; metal



clad buildings in the vicinity of airport ground control radar can adversely effect operations, reflective/adsorptive properties should be considered carefully.

Lessons gleaned from the operation and maintenance of completed facilities may be too late to benefit that facility but are potentially useful on subsequent facilities. By definition, POE's occur after completion of a facility or structure. Benefits accrue when these lessons are utilized early in the planning, design and construction of subsequent facilities and structures.

Following the axioms postulated by the Construction Management Committee of the ASCE and the CII, this research proposes a practical method to realize some of the goals of a constructability program, focusing on lessons-learned in the **construction** phase. This construction knowledge has the potential to be utilized in all phases of the project life-cycle. We make use of highly knowledgeable, significantly experienced, construction experts to examine the issue of classifying construction knowledge. Chapter three examines various efforts to collect and disseminate knowledge gained in the architecture/engineering/construction world.



### CHAPTER III - BACKGROUND AND RELATED WORK

To investigate the state of the art in engineering-construction feedback systems, letters were sent, and follow-up phone calls were made to various universities, colleges, organizations (CII, ASCE, AEPIC) and construction firms who have historically conducted research or performed work in this area. The response rate of over 60 percent was encouraging. Finally, personal interviews were conducted.

Many professional organizations have initiated efforts to collect and disseminate failure and performance information in specific disciplines and specialized fields: soil and foundation engineers (ASFE), fire protection engineers (NFPA), National Bureau of Standards (NBS), the Committee on Large Dams (COLD) of the ASCE, and the National Transportation Safety Board (NTSB) for the Federal Aviation Administration (FAA).

On an inter-disciplinary level, the Architecture and Engineering Performance Information Center (AEPIC) at the University of Maryland [Vannoy, 1983], the Journal of Performance of Constructed Facilities of ASCE [Carper, 1987], and the Center for Excellence in Construction Safety at West Virginia University [Eck, 1987] have attempted to integrate lessons-learned from the performance of constructed facilities into industry practice. We are concerned with performance





information spanning all trades and disciplines in an engineering/construction context.

While many organizations have formal or informal methods of obtaining and utilizing feedback in the DESIGN arena, relatively few attempts have been made to collect, classify, or disseminate lessons-learned from the CONSTRUCTION phase of the project life-cycle. Although the following systems are not construction oriented, the various approaches and classification systems developed by these architecture and engineering professionals are analyzed to gain insight into the essential elements of a successful system. A description and critique of various existing systems is presented below.

Much of the work in this field has been done by forensic engineers. Before delving into these systems, it is imperative to clarify the vocabulary that will be used. In the context of forensic engineering, failure is defined as "an unacceptable difference between expected and observed performance" [Carper 1989]. These failures range in scope from mundane roof leaks to notorious disasters like the failure of the Teton Dam (1976) and the Kansas City Hyatt Regency (1981) walkway collapse.

Minor failures are much more frequent and their cumulative economic effect is more significant. . . It has been suggested that the use of words such as "incident" or "accident" rather than "failure" might encourage discussion of these less spectacular performance problems. The dam and nuclear industries have found it necessary to develop such a vocabulary to deal with events which are less than catastrophic [Carper, 1987].



## Architecture & Engineering Performance Information Center

Mr. Neal FitzSimons began the seminal work in forensic engineering performance classification systems in 1964. He subsequently published "Making Failures Pay" [FitzSimons, 1981] and, along with Prof. Donald Vannoy, initiated what was to become the Architecture and Engineering Performance Information Center (AEPIC) at the University of Maryland. The mission of AEPIC is summarized in Architecture and Engineering Performance Notes:

The initial objective of AEPIC . . . is the improved design, construction and performance of buildings, civil structures and other constructed facilities. That objective is based on the premise that collection, analysis and dissemination of information on performance . . . will assist in the improvement of the built environment . . . [AEPIC 1, 1988].

In 1986 AEPIC began to collect information from two major sources to incorporate into the first computerized depository for failure data of this type. The first source was case files from one of the primary companies providing liability insurance for architects and engineers. The second source was Federal and State Appellate Court case summaries involving building and civil structure failures [AEPIC 1, 1988]. The AEPIC system is one of epic proportions with over 4,000 coded cases. This scheme has 67 different data fields [Appendix A] covering numerous of topics, including the parties involved, ordinary project information, extraordinary project details such as the size of the component, property damage, bodily injury/death, and the location, cost, catalyst and cause of he



incident.

The AEPIC Dictionary of Quick Codes is included as Appendix A. As the data fields illustrate, this system catalogs performance incidents from the perspective of a forensic engineer. The original vision was for an all encompassing database of performance information, but the current system is constrained by it's sources of information. Given the sensitive nature of information dealing with actual or alleged failures and litigation, it is very difficult to acquire factual data. Claims cases, purged of incriminating information to protect privacy, are perhaps the only realistic source of large scale data of this sort.

Some of the AEPIC data fields are not applicable to a feedback system customized for construction, but two are noteworthy. The PROJECT USE category defines the purpose of the facility and is split into two broad categories: Structure/Civil and Buildings. A comprehensive list is provided for each. AEPIC utilizes the broad categories of construction outlined in the CSI Divisions but further refines them by adding a COMPONENT/ELEMENT category to cover such things as walls, floors and specific systems. Although this particular classification system is failure oriented, it represents considerable thought in its comprehensive structure.

The volume of encoded information facilitates the analysis of trends over time. The results have been published



in a series of newsletters with various graphical summaries. Performance failure trends were identified and analyzed. For example, siting and excavation problems make up 18 percent of all performance incidents in terms of property damage and management problems. Roofing problems account for 10 percent of the reported failures. Of the roofing failures, 61 percent involve water penetration while 35 percent involve structural failure [AEPIC 4 & 5, 1988].

This classification system is by far the most elaborate developed to date. At its inception, there was tremendous enthusiasm, excitement and support in the trade journals, but in recent years the AEPIC system has not enjoyed widespread use. The objectives are clear and worthwhile, but the system seems to lack focus, and integration into actual practice has not occurred.

The AEPIC target audience is vast and includes architects, engineers, contractors, developers, manufacturers, lawyers, building owners and users, federal and state agencies, insurance underwriters, university and private research organizations and others [Loss 1987]. There are a myriad of potential uses, but no specific customer. The sources and volume of encoded information make the database effective for research and analysis of trends, but perhaps too broad and unfocused for individual clients.

The AEPIC system was initiated almost ten years ago, employing basic database technology. Recent advances in





knowledge based expert systems, hypermedia techniques, and interactive graphical user interfaces (windows) can now be incorporated into feedback systems such as AEPIC to encourage direct user interaction.

### American Society of Civil Engineers

Various committees of the American Society of Civil Engineers have collected and categorized information regarding failures, accidents and performance of dams and hydraulic structures for many years ["Lessons," 1975; "Lessons," 1986]. Each publication contains case studies collected through questionnaires and generally includes a narrative description of the structure and the incident. Although substantial work has gone into collecting and disseminating performance information related to hydraulic structures, no attempt at a comprehensive classification system has been made.

The Journal of Performance of Constructed Facilities, is published by the ASCE and jointly sponsored by the National Society of Professional Engineers (NSPE/PEPP) and AEPIC. As the first jointly sponsored journal, its objective is the development of professional practices to improve quality and promote public confidence in the engineering design professions. Published since 1987, this journal "seeks to coordinate and expand failure information dissemination strategies" [Carper, 1987].

The journal has featured case studies of performance



failures, as well as a spectrum of professional views on alternate dispute resolution methods. The recent explosion of litigation has prompted engineering professionals to not only consider methods to reduce failures, but to explore creative ways to resolve the disputes that consequently erupt.

Currently, there is no industry standard for classifying performance information. David Nicastro, and the Committee on Dissemination of Failure Information of the ASCE Technical Council on Forensic Engineering is currently studying the matter and hopes to adopt a taxonomy for classifying performance data. He is implementing an expert-system that will incorporate the work done by AEPIC and others, but will go beyond all of the resources of which we are currently aware in systematically classifying failures. In a recent letter, David Nicastro notes:

A common problem with previous classification systems is that they generally start out by pigeon-holing the failure, and then describing its characteristics. For development of a computerized expert-system, the opposite approach is required. Our system is based on a parameter tree model, whereby the characteristics of a failure are checked against a list of parameters, and the sum of the characteristics defines the failure.

The committee hopes to adopt a uniform system for classifying failures, similar to the well known biology taxonomy (kingdom, phylum, species). It believes that the adoption of a common structure by ASCE would be a major step toward industry standardization and would be an enormous benefit for communication and research.



## U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (CERL) has developed two systems to improve constructability through design review. The first, Automated Review Management System (ARMS), was developed to help managers track constructability and design reviews of construction projects with the major participants being geographically dispersed. ARMS manages review deadlines at all user levels, provides database management for comment manipulation and analysis, provides for electronic forwarding of comments, and permits on-line or off-line batch comment generation and uploading using standard word processors [Kirby, 1991]. This system is designed as a management tool, and aids in the constructability process, but does not actually contain performance information.

The follow-on system, currently under development, is called BCO Advisor: Expert System for Biddability, Constructability and Operability Review. It is a personal computer based hypertext system designed to help U. S. Army Corps of Engineers personnel perform constructability reviews on construction design documents. The prototype system employs the KnowledgePro expert system shell. It uses a menu-driven knowledge base program with hypertext as the shell for interactive checklists. The user interactively compiles a tailored checklist based on the design stage (35% design, or



95% design) and discipline or CSI division of interest, for later printing. This customized checklist is then used to review the design of a particular project. The prototype contains over 2500 individual comments (check-list items) from various sources, over half of which deal with "routine design construction evaluation" [Kirby, 1991].

The BCO Advisor has a different goal than our construction lessons-learned system. It is design oriented and produces a checklist, while our system endeavors to harness construction expert knowledge. It utilizes a review comment (coordinate roof openings on architectural, structural and mechanical plans) rather than a performance lesson (ensure curing compound used on roof slab is compatible with proposed roofing system) as the basic unit of knowledge.

BCO Advisor is, however, instructive from two points of view. First, it is technically sophisticated and effectively utilizes a KBES with hypertext to rapidly retrieve appropriate comments in an extremely user friendly environment. Second, it is well integrated into the existing operations of the Army Corps of Engineers. Previously, engineers performing design reviews had to root around for an appropriate checklist, or rely on their memory for the myriad details to be reviewed. Upon completion, the comments had to be packaged and mailed to the responsible agency. With the BCO Advisor, a checklist can be interactively compiled, annotated with comments as the review progresses and mailed electronically. It fits nicely





into the traditional method of accomplishing the task, yet improves productivity.

### **Naval Facilities Engineering Command**

The Design Division of the Naval Facilities Engineering Command has initiated numerous attempts to gather and classify lessons-learned in the design and engineering of facilities for the Navy. Dr. Michael Yachnis, former Chief Engineer, assembled and published a book in 1985 with over one hundred lessons titled "Lessons Learned from the Design & Engineering of Naval Facilities" ["Lessons," 1985]. It is generally organized by discipline (structural, architectural, mechanical), but includes some problematic areas of concern to the Navy (corrosion, cranes, welding & non-destructive testing, and physical security). Each lesson includes the problem, symptoms, collection of facts, and solution as well as sketches where applicable.

Numerous follow-up efforts by the Navy's Design Division have resulted in a number of local systems, including: "Design and Maintenance Observation Feedback System." This system has two components. The first is a database of design criteria feedback from all possible sources, accessible by discipline or by a five digit category code (cat-code). Cat-codes are used by the military to represent very specific facilities (aircraft parking apron, brig, B-52 flight simulator, transmitter building, guided missile spares storage). The



second component contains maintenance feedback, organized by cat-code. It is derived from various sources, though predominantly post occupancy evaluations.

This system and others were considered working prototypes but suffered several short-comings. Their capacity was limited by the software, but was adequate for the start-up phase. A formal method of collecting and inputting the observations was missing. Data collection was sporadic and the quality of the observations was inconsistent. The system was physically located at headquarters, but most of the raw data occurred at the field level. The system was a stand alone; it was not integrated with existing software or procedures. Updating the system required extra effort from a project engineer or a dedicated data entry person.

Drawing on the lessons of their previous attempts, Mr. Tom Hurley, at the Design Division of the Naval Facilities Engineering Command, has developed an exemplary value engineering database. This system has gained widespread use in the Navy in the last year. It is written in "C", uses Clipper database software, and stores information on compact disks. The results of value engineering studies conducted at various Department of Defense field activities around the world are submitted on floppy discs and batch loaded into the Navy's corporate database. This system scores high marks for integration into the existing method of doing business. The database grows from a regular diet of "accepted" value



engineering comments, currently over 16,000. Like the Navy's Guide Specifications, it is distributed on read-only compact disks.

Target users are anyone in the Department of Defense that designs new facilities. Current Navy policy requires all such designers to conduct "0%" value engineering review. Before commencing design, they simply review the accumulated value engineering suggestions by cat-code, for the type of facility under consideration. Project specifications are developed by computerized cutting and pasting and both guide specifications and value engineering lessons are located on the same menu.

This value engineering database overcame the integration problems and was developed with an appreciation of the big picture, or the overall mission of the organization. It's weakness lie's in the collection and verification of data. Many valid value engineering comments are not "accepted" for a particular project because of the advanced stage of design. Acceptance would essentially require redesigning the facility. These "rejected" comments are not appended to the database, although they may be beneficial. Other accepted comments may be appropriate for a facility in one location, but inappropriate in a different location. The system has no way of sorting or classifying except by cat-code and discipline. It relies on the user's expertise to judge the appropriateness of each comment.



## International Work

A number of international organizations exist that are pursuing work in failure information dissemination. A review of international publications revealed extensive case studies and compilation of failure data, but did not reveal any information about specific classification systems. Major international organizations include: the Building Research Establishment (BRE) of the United Kingdom; National Research Council of Canada; BYGGDOK, a Swedish organization; the National Timber Research Institute of South Africa; and SOCOTEC, a French organization [Carper, 1987]. Other work was done by Raikar in India [Raikar, 1987] and by Matousek in Switzerland [FitzSimons, 1978].





## CHAPTER IV - CHALLENGES OF EFFECTIVE FEEDBACK SYSTEMS

The problems discussed in the preceding chapter illustrate a common theme among various attempts to collect and utilize lessons-learned from the field. Some progressive construction firms and facilities management organizations have attempted to benefit from accumulated construction knowledge and expertise, and typically synthesize experience into a checklist. Previous efforts to effectively utilize lessons-learned were thwarted by the following:

- (1) Lack of a meaningful classification system.
- (2) Unmanageable format that made it difficult to access and retrieve the potentially enormous volume of lessons.
- (3) Failure to effectively integrate the new scheme into the existing operations of the organization.

These challenges will be addressed in turn below.

### The Classification Challenge

Principal difficulties in establishing a common classification system include the vast spectrum of potential end users and the different information each considers pertinent. The first level of divergence occurs at the phases of construction: conceptual planning, design, construction and operation/maintenance. Architects tend to group information by discipline: architectural, structural, mechanical, electrical.



Construction practitioners are more comfortable with the 16 CSI Divisions: site work, concrete, masonry, etc.

The second level of divergence relates to the many different types of constructed works. The broad categories are civil structures and buildings [Table 2.]. Civil structures run the gamut from culverts to dams to industrial complexes. Buildings span a wide range in both size and complexity, from single family homes, to high rise towers. Specialization breeds different requirements for information. The dam builder and highway contractor are both concerned with soil conditions, but each at a different level.

Another consideration is the quality or depth of the lessons. These range from superficial, or common sense (don't leave unsecured styrofoam insulation pallets on non-enclosed upper level decks on windy days) to highly technical (an M-60 machine gun firing 7.62-mm ammunition at a distance of 25 yards will not penetrate an 8" cast concrete wall with #5 rebar @ 6" on center with a 10 gauge (3.4 mm) steel front panel).

### **Accessibility and Retrieval of Information**

While checklists of the BCO Advisor and Redicheck [Nigro, 1983] variety can be useful aids in reviewing contract plans and specifications, they do not follow the spirit of constructability. The goal is complete integration of the design/construction effort, bridging the traditional gap.



After the fact design review, implies essentially separate design and construction. To contribute to constructability, the basic unit of knowledge must be an easily accessible, specific lesson (fiberglass dome pans are superior to metal pans), not a general review recommendation (coordinate all mechanical and electrical drawings).

To be truly effective, the system must be appropriate for both designers and constructors. The lessons must be organized for rapid retrieval in a variety of ways (key words, CSI division, component). Recent advances in both hardware and software have contributed to the tools available to construct such a successful system. Lightweight, portable computers are available and easily transportable to the field, with the speed and memory to handle the demands of an enormous database. Software tools such as expert system shells and hypertext capability provide the reasoning, explanation facility and user interface essential to user acceptance. Object oriented programming, now in the early stages of development, will provide an even greater opportunity to link and access related lessons and facts in the future.

Almost all previous attempts to utilize construction feedback have followed the checklist format. In an effort to efficiently input construction knowledge back into the facility life-cycle, we will shun the checklist approach in favor of database or knowledge based expert system formats.



## Integration

Perhaps most importantly, a feedback system must be integrated into the way the users (designers and constructors) perform their work. Consider this scenario: as a designer extracts a specification section on reinforced concrete, dome slab construction, from a guide specification, the lessons-learned knowledge base would automatically retrieve the applicable lessons for the designer to peruse and apply as appropriate. How about a project superintendent preparing his schedule for the following week? He knows cold weather is forecast, so he queries the system using cold weather concrete as the keyword and discovers that the mix he intended to order won't flow through the pump below a certain temperature.

Complete integration of a lessons-learned knowledge base into the existing procedures and methods of doing business is not easily achieved. There is a danger in developing a new system of any kind that requires dedicated personnel or demands large chunks of time from already overburdened schedules. Higher priorities and personnel shortages, endemic in today's economic environment, will doom a system that is not easily integrated into existing methods or procedures. For these reasons, speed, ease of use and user friendliness are pivotal in the success of a new system.

When dealing with the introduction of a new system that happens to be computer based, the major barriers are often psychological. There is a reluctance in established businesses





to relinquish manual control or to experiment with emerging technology. While lap-top personal computers may be struggling into some corporate board rooms, many project managers and superintendents are still not computer literate. This only complicates the already formidable integration challenge.

Another important aspect of integration is a grasp of the big picture, or what management specialists call vision. It is crucial to first seeing and then exploiting the potential in any feedback system. We have seen several feedback systems initiated by well intentioned, motivated, individuals that work from the perspective of their particular niche in the firm, but lack the big picture perspective. Technical sophistication is common, but adequate classification and integration are lacking. Lacking this vision, the system may serve well in it's niche, but will fail the overall organization. The goal, after all, of feedback is to achieve the widest possible dissemination and hence benefit of expert knowledge accumulated by the entire firm.

In an effort to better grasp the big picture and integration issues, we enlisted the participation of the research and development committee of a medium size construction company. Input and ideas came from various experts including field operations, project management, research, computing and accounting, construction yard and shops and upper management. The result was a confirmation of the value and direction of the feedback system.



## **Accentuate The Positive**

Facility performance, like feedback and lessons-learned, can include both positive and negative experiences with constructed facilities. However, since most of the effort in collection and classification of performance data has been undertaken by forensic engineers, the focus has been on failures, as previously defined.

This research focuses on lessons-learned during construction. While some of the lessons will undoubtedly involve failures or incidents, the majority will convey positive experiences or advice: methods to optimize productivity, methods to obtain the flattest possible floor, optimal deck space served by a tower crane, and innovative slip form construction. The result of a knowledge based feedback system developed by construction experts will be a corporate knowledge base. The benefits of such a system are well established.



## CHAPTER V - THE DEVELOPMENT OF A KNOWLEDGE BASED INFORMATION SYSTEM FOR CONSTRUCTION

As discussed in Chapter II, there are numerous potential feedback channels in the project life-cycle. The primary focus of this research has been lessons that have their genesis and application in the construction phase. While considerable effort has been exerted in developing classification and dissemination strategies almost no work has been dedicated to the construction phase.

In the construction arena, solid lessons are very difficult to extract and collect. For this reason there is a paucity of documented construction knowledge. Successful project managers and superintendents have developed their own individual methods and procedures, proven effective by their longevity in this highly competitive market. Because of their tenacity and success, it is often difficult to achieve a consensus attempting to compile the best methods, products or procedures. This difference of opinion further complicates the process of verifying and validating lessons from the field.

Many firms and organizations synthesize experience into checklists. Specific knowledge and experience is generalized into planning tools. While checklists can certainly be beneficial, other formats can optimize the value of construction feedback. We follow the constructability dictum



that early feedback of construction expertise into all phases of the project life-cycle will achieve the greatest benefits. The optimum format for such a system preserves the integrity of each individual chunk of knowledge or lesson.

The goal of this research is to develop a model of an effective lessons-learned knowledge base for a medium or large size construction firm. Essential elements of the system include (1) a meaningful classification system, (2) knowledge acquisition, or a mechanism for collecting, verifying and inputting information, and (3) implementation and integration into existing operations.

### **A Classification System For Construction**

The goal of the classification system is to categorize all pertinent data or lessons in such a way that they can be efficiently retrieved in a number of possible manners. Since this effort is tailored for construction rather than design professionals, the basic building block of the system is the CSI Division, further defined by the component within the Division. The basic categories of data are:

- A. Project Information
- B. Stage of Project
- C. Project Use: Structure/Civil or Building
- D. CSI Division
- E. Component
- F. Lesson: Problem, Solution, Explanation, Key words





## G. Source

The classification system model is illustrated in Figures 2 & 3. The **project information** fields would be tailored to the particular construction firm. By including the various **project stages**, the system is flexible enough to accommodate all members of a project management team. It would also be beneficial to owners of large facilities inventories and construction savvy owners, engaged in partnering.

The next level, **project use**, diverges into the two broad categories of constructed works: Structure/Civil and Buildings. The particular specialization of the construction firm would probably focus on a limited segment of **project uses**, but a representative list of possible uses is contained in Table 1. Both the component and project use breakdowns, have been adopted from the AEPIC classification system, "Dictionary of Quick Codes" shown in Appendix A.



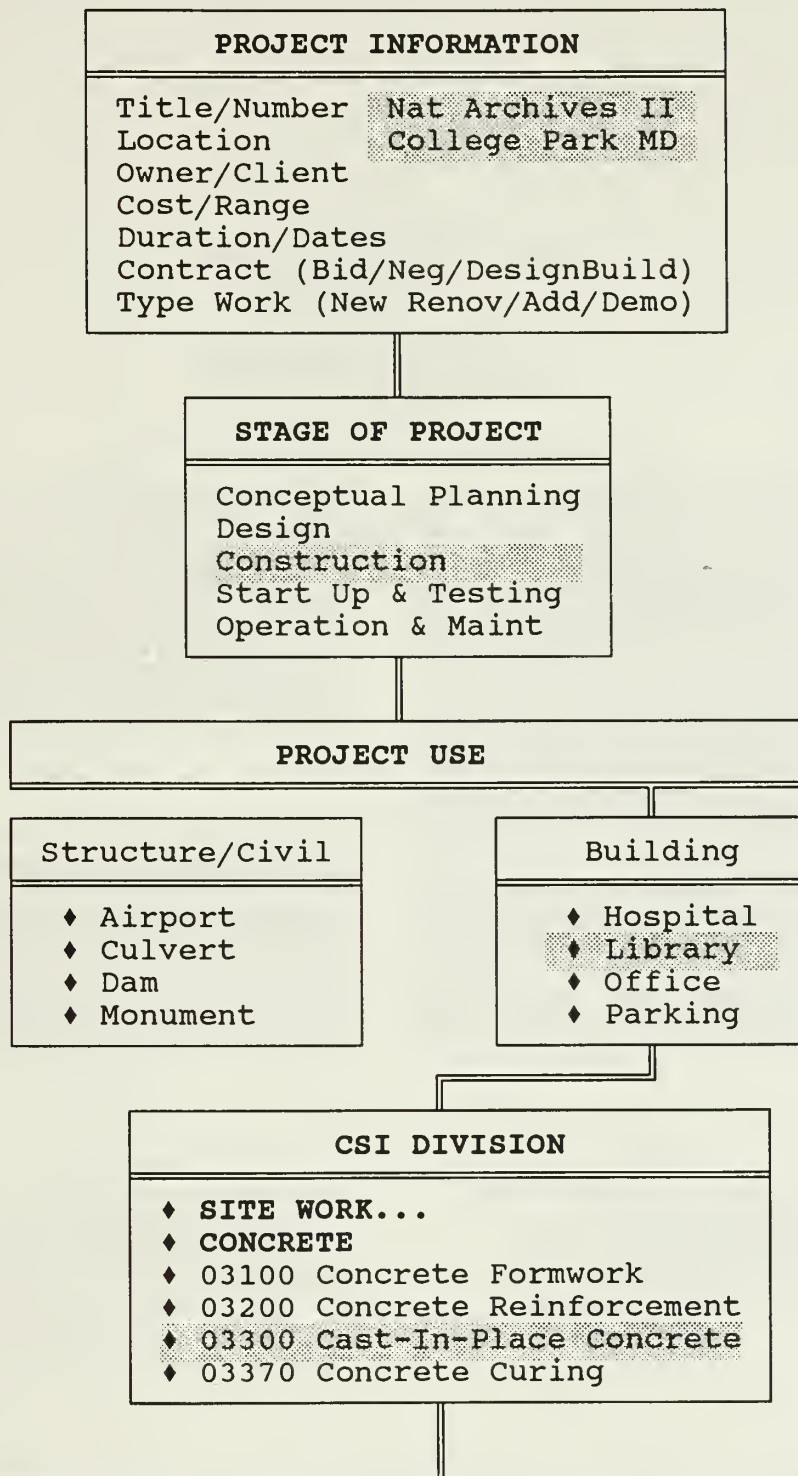
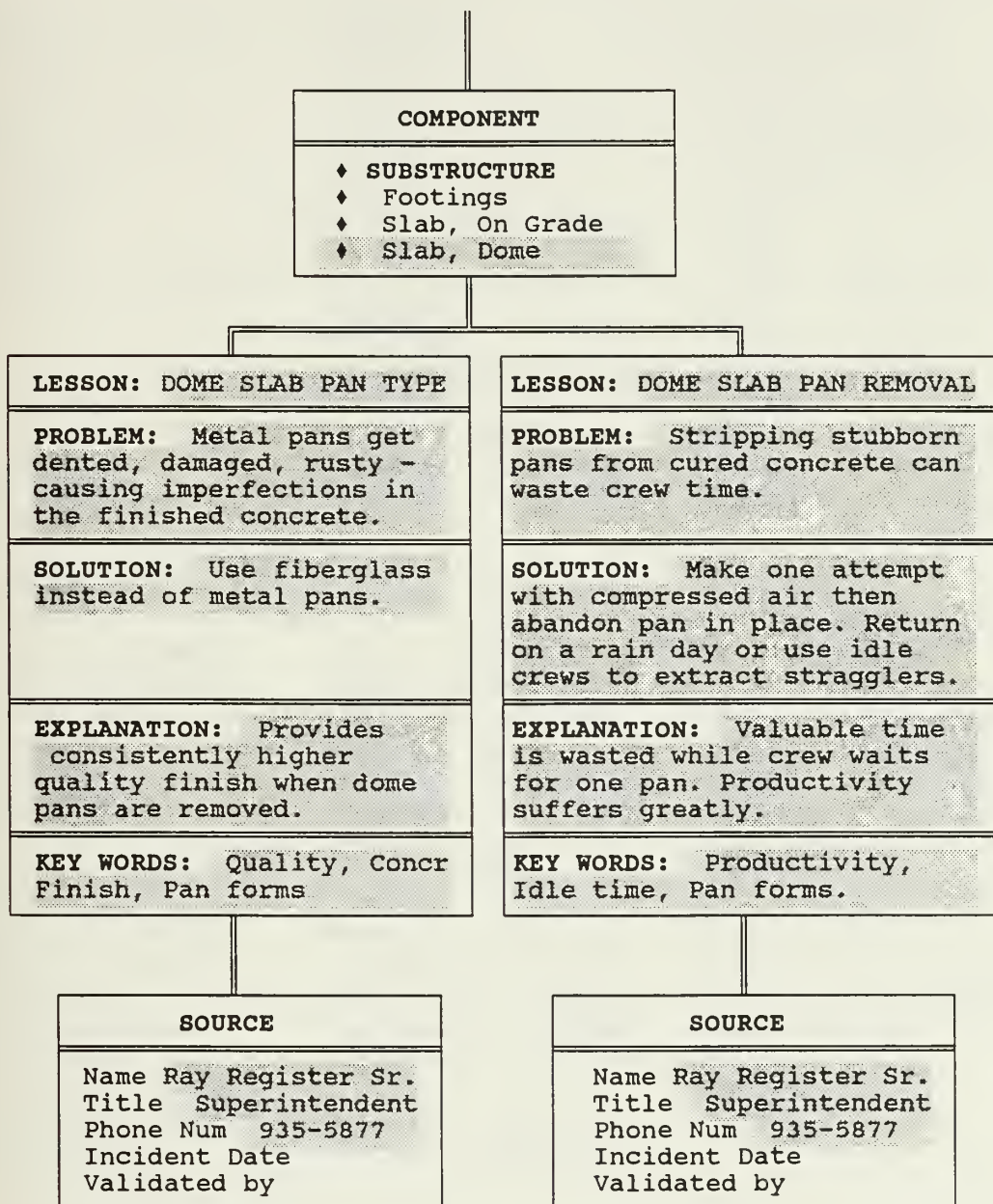


Figure 2. Classification System, Part I





**Figure 3. Classification System, Part II.**



## CLASSIFICATION SYSTEM - PROJECT USE

### STRUCTURE/CIVIL

Special	Excavation	Retaining Wall
Airport, Nav Aid	Formwork	Scaffolding
Airfield	Foundation	Seawall
Bin, Silo	Harbor, Jetty	Sewage, Waste
Bridge, Trestle	Harbor, Terminal	Stack, Chimney
Cableway	Highway, Road	Subaqueous Str.
Comm Dish	Hoist, Crane	Swimming Pool
Causeway	Hydraulic Struct	Tank
Cemetery	Incinerator	Tower, Cooling
Containment Vessel	Irrigation Sys	Tower, Freestd.
Culvert	Lighthouse	Tower, Guyed
Dam	Monument	Tunnel, Subway
Derrick	Offshore Structure	Wall, Barrier
Dike, Levee	Park/Playing Field	Water Tower
Dock, Wharf	Parking Area	Water Processing
Drainage Works	Pipeway, Distr Sys	Waterway
Elect Generation	Railway	Reservoir
Embankment	Refinery	

### BUILDINGS

Agriculture, Barn	Education, Higher	Nursing Home
Airport Terminal	Field House, Gym	Office Building
Airport Freight	Freight Terminal	Parking Structure
Apartment	Funeral Home	Postal Facility
Arena	Grocery Food Store	Public Building
Auditorium, Theater	Hospital, Special	Prison
Bank	Medical Facility	Recreation Fac.
Chemical Plant	Hotel/Motel	Refrig. Facil.
Civic Building	Housing, Duplex	Religious
Commercial, Retail	Housing, Townhouse	Restaurant
Computer Facility	Housing, Detached	Service Station,
Condominium	Industrial, Heavy	Shop Center/Mall
Convention Hall	Industrial, Light	Stadium
Courthouse	Laboratory, Research	Transportation
Dormitory	Library	Warehouse
Education, Elem,	Museum, Gallery	
Secondary	Nuclear Facility	

Table 1. Classification System, Project Use





**CLASSIFICATION SYSTEM - COMPONENT**

<b>SITE, SUBSTRUCTURE</b>	<b>INTERIOR, cont</b>
Excavation, Grading	Horizontal Circulation
Compaction	Vertical Circulation
Sheeting	Core
Piles, Caissons	Spaces
Drainage	Surfaces
Bedding	Contents
Tunnel Lining	Ceiling
Retaining Wall	Finishes
Dam	<b>TEMPORARY CONSTRUCTION</b>
Cofferdam	Bracing
Slurry Wall	Shoring
<b>SUBSTRUCTURE, FOUNDATION</b>	Formwork
Abutment	Scaffolding
Footings, Line	Equipment
Footings, Mat	Fireplace
Footings, Column	Trailers
Pier	Storage Units
Wall	<b>MECHANICAL/ELECTRICAL SYS</b>
Buttress	Cooling
Pile Cap	Heating
Slab, Dome	Ventilation
Slab, On Grade	Plumbing
<b>STRUCTURE</b>	Lighting
Membrane	Transport
Continuous Structure	Hazard Detection
Vertical System	Emergency Power, Supply
Horizontal System	Power
Anchorage	<b>PAVING, LANDSCAPE</b>
Connection	Walkway
Joint	Roadway
Arch, Shell	Runway
Suspension	Bridge Deck
<b>EXTERIOR ENVELOPE</b>	Channel Lining
Paint	Trenching
Roof	Drainage
Window	Fence/Wall
Door	Plant Material (Natural)
Wall Panel	<b>SPECIAL CONSTRUCTION</b>
Insulation	Marine Installation
Waterproofing	Oil, Gas
Flashing	Tower, Stack, Chimney
Caulk, Sealant	Water Containment
Vertical Circulation	Toxic Materials Handling
Horizontal Circulation	Low Voltage Electricity
<b>INTERIOR</b>	High Voltage Electricity
Wall	Sewage Treatment
Floor	Crane, Boom

**Table 2. Classification System, Component**



**CSI Division** provides the general classification framework, but is still too general for pin-pointing areas of interest. **Components** within the CSI Division, Table 2, have been added to further isolate the lesson. The basic unit of the classification system is the **Lesson Learned**. It has a title, and brief narratives describing the problem, the solution, and an explanation. It is further referenced by key words to allow maximum versatility in querying the system. Finally, the Lesson is credited to a **source**, again tailored to the user institution.

The explanation facility is critical to a credible system. Telling intelligent construction practitioners that a certain method is superior to another, without providing a rationale, will not create believers. Listing the source adds credibility and provides a resource for further investigation when necessary.

### **Methods of Inquiry**

If a user cares to peruse all the lessons pertaining to a particular type of facility, parking structures for example, he simply enters **project use**, and **buildings** then selects **parking structures** from the menu. This method can be used to gain familiarity with a new type of structure or construction method.



To learn about concrete, one can browse through the **CSI Divisions** until he finds concrete. If this topic is too broad, it can be narrowed to cast-in-place concrete by selecting **CSI** section 03300. To further narrow the search slabs or footings could be chosen from the **component** menu.

Some subjects, such as roof leaks, can occur in any number of facilities and cross many **CSI Divisions**. To accommodate queries of this nature, **key words** are utilized. **Key words** can also cover conditions like cold weather concreting and issues such as productivity or quality.

### **Knowledge Acquisition and Knowledge Engineering**

Extracting expert knowledge from subject matter, or domain experts is perhaps the most difficult step in the development of any knowledge base. "Knowledge acquisition has been reported as the major bottleneck in the development of expert systems" [Bowen et al. 1990]. Experience in knowledge engineering has shown that questionnaires are not effective. For this reason, we elected to pursue unstructured interviews as the primary method of knowledge acquisition. Key issues covered during initial interviews included: existing lessons-learned systems, quality improvement initiatives, years and type of experience, areas of expertise, familiarization with computing technology and existing computer hardware and software, constructability, design-construct experience, construction performance and failures.



The goal of this research was not to accumulate a vast library of construction knowledge, but rather to collect a sample of lessons from various construction disciplines as a point of departure for the development of a classification system. The interview process itself was critical to gaining an understanding of how successful project superintendents approach their business. It allowed insight as to how they categorize, organize and utilize their rich experience. Heuristics, or rules of thumb, are plentiful in construction, but as always, difficult to articulate.

After an extensive literature search, interviews were conducted with a number of experienced construction managers, including project executives, project managers, superintendents, and foremen. Due to their hectic, unpredictable schedules, initial interviews were conducted by simply spending the day following superintendents around job sites. As areas of personal expertise became apparent, further questioning in those areas was pursued. Daily project dilemmas provided other opportunities to gain insight into frequently applied heuristics and problem solving mechanisms. It was immediately apparent that extraction of valuable lessons requires much patience and persistence.

The classification system was developed based on the format these construction experts used to articulate their rules of thumb. For example, when discussing how much concrete to leave in the hopper of a pump truck, the discussion took





place in the context of a particular facility (PROJECT USE). The facility was essentially built from reinforced concrete (CSI DIVISION), the COMPONENT was a topping slab, and the method was pumping (LESSON TITLE). The lesson itself consisted of a brief narrative description of the problem, the solution and an explanation. To accommodate broad issues that span many divisions or trades, such as the quality of the finished concrete, KEY WORDS were included.

Collection and verification methods that rely on the good will of potential users to input applicable information when they have time to do it, have proven ineffective. A structured approach to data input and verification is essential. Routine status reports and meetings as well as various project milestones, provide the ideal opportunity to reflect upon and input lessons-learned.

Based on this research, it is apparent that a dedicated collector of lessons will be required to establish a working prototype. The frantic pace of operations at the project site requires an individual free of daily project pressures to concentrate on building the firm foundation required for such a system. Once a prototype has been developed, it can be demonstrated to potential users. The ease of use and potential benefits will help sell the system to the users, encourage experimentation and lead to faster acceptance of the system. It is imperative to establish a credible prototype with which to lure in skeptical users and reluctant experts.



## Implementation Issues

The myriad of potential lessons-learned and construction knowledge can be organized, stored and accessed most efficiently utilizing knowledge processing and hypermedia techniques. The heuristics (rules of thumb based on experience) gathered from construction experts can be organized using the classification system and incorporated into a knowledge base. The result of this task is a common pool for storing, retrieving, modifying, interpreting and reasoning with constructability knowledge.

The first function of the system will be to obtain the project of interest. This single piece of data will cause the system to link to a block of applicable rules. Entry of the World Bank project, for example, would trigger project use data and link to multi-story, cast in place concrete structure, multi-level basement, severely constricted site. This information would activate rules dealing with multi-story concrete structures etc. Rules about steel frame structures would not be activated, while rules about slurry wall construction, and soil anchors would be activated. This linkage of basic project data serves as a first cut to narrow down the field of potentially useful lessons.

The next step would be to query the user for the situation at hand. Information regarding the stage of construction, applicable CSI Divisions, and work component would be solicited by sequential menus. This will provide a



direct link to the classification system, accessing all applicable rules.

The user interface is a critical component to any interactive system. In this case, it is essential to provide the user with an explanation facility. Without such a capability, the integrity of the system is suspect to the new user. A basis for each particular lesson is required, relating to time, cost or quality. This explanation facility will also prove indispensable when debugging or validating the system as it evolves from a prototype to a mature system.

Wherever they exist, alternative solutions to problem situations should be provided. There generally is not one unique, universally accepted solution to any construction predicament, and an alternate solution may be more appropriate considering the peculiarities of a given situation.

**Software.** A wide variety of database application software is commercially available. Most are programmable to some extent and all can be customized for individual applications. The emerging technology that is best suited for a lessons-learned knowledge base, however, is expert system shells. BCO Advisor, discussed in Chapter III, employed such software. A review of currently available, microcomputer-based expert system shells (ESS) suggests several suitable options. KNOWLEDGE-PRO, LEVEL 5 OBJECT, KAPPA PC, and VP EXPERT all offer hypertext capability, windowed interface, advanced programming capabilities and rule based knowledge



representation. Because new products are being introduced monthly, it is difficult to make definitive recommendations. The essential elements of an ESS for this application would be hypertext capability, windowing capability, rule or frame based reasoning and possibly object oriented programming.





## CHAPTER VI - CONCLUSION

Historically, the collection and dissemination of engineering/construction knowledge has proven to be difficult but invaluable when accomplished. The main contribution of this research has been to demonstrate the feasibility and potential benefits of making effective use of construction lessons-learned by developing a knowledge based model from actual construction experience. Key challenges to effectively utilizing feedback channels in the project life-cycle were identified along with methods to meet these challenges.

The CII has called for improved documentation of lessons-learned from the field. The model presented in this thesis will accomplish this goal. The benefits of an effective feedback system are numerous. Although construction of a facility is typically viewed as a one of a kind operation, there is a considerable amount of repetition. Facades, bays and often entire floors are repeated. Lessons acquired in one project by a particular crew, must be communicated to other crews on the same project as well as to other projects. As the CII advocates, a corporate lessons-learned database is a key element in any constructability program.

The significance of such a system is not limited to improvements in cost, time, quality and safety of construction projects. It will also enhance construction education by



providing students with fresh examples from actual construction projects.



## APPENDIX A

### AEPIC DICTIONARY OF QUICK CODES



## DICTIONARY OF QUICK CODES

ARCHITECTURE AND ENGINEERING PERFORMANCE INFORMATION CENTER  
(Information Not Available XX; None 00)

### A. DATA

### SOURCE DS

10 AEP1C  
20 FIRMS  
21 Architecture and A/E  
22 Landscape Architecture  
23 Engineering and E/A  
24 Land Engineer  
25 Construction  
26 Owner  
27 Legal  
28 Insurance  
29 Testing  
30 Manufacture  
31 Supply/Distribution  
32 Land Surveyor  
33 Forensics  
34 Construction Management  
35 Quantity Surveyor/Estimator

40 SOCIETIES/ASSOCIATIONS/  
INSTITUTIONS  
41 Architecture  
42 Landscape Architecture  
43 Engineer  
44 Land Engineer  
45 Construction  
46 Owners  
47 Legal  
48 Insurance  
49 Testing  
50 Manufacture  
51 Supply/Distribution  
52 Land Surveyor  
53 Education

60 PUBLICATIONS/MEDIA  
61 Technical  
62 Professional  
63 Popular  
70 GOVERNMENT  
71 Federal  
72 State  
73 Local  
74 Foreign

### TYPE DT

01 Article, Published  
02 Bibliography, Search Index  
03 Conference Report, Proceeding  
04 Directory, Dictionary  
05 Environmental Analyses, Filing  
06 Financial Report, Fiscal Matter  
07 Guide, Handbook  
08 Hearing, History  
09 Investigation, Inspection, Research  
10 Journal, Collected Case Histories  
11 Contract, Agreement  
12 Law, Legislative Document

13 Major Dossier, Case, Claims  
Document  
14 Map  
15 Opinion, Case Law, Decision,  
Ruling, Dicta  
16 Policy Statement, Position Paper  
17 Model  
18 Regulation, Rule  
19 Specification, Code  
20 Trial, Litigation, Brief,  
Memorandum

21 Textbook  
22 Photo, Slide  
23 Drawing  
24 Film, Video  
25 Working Paper, Analysis  
26 Exhibit  
27 Yearbook  
28 Graph  
29 Interview

### CLASS DC

01 Design  
02 Construction  
03 Testing, Research  
04 Structure

05 Materials, Products  
06 Information Science, Computers  
07 Legal Matters  
08 Insurance, Risk Management

09 Finance Statistics  
10 Quality Control  
11 Quality Assessment





## B. LOCATION

COUNTRY OR STATE IN WHICH DAMAGE OCCURRED LD  
COUNTRY OR STATE OF FIRM'S OFFICE LF

AF	Afghanistan	FJ	Fiji	MY	Malaysia
AL	Albania	FI	Finland	MV	Maldives
AG	Algeria	FR	France	ML	Mali
AQ	American Samoa	FG	French Guiana	MT	Malta
AN	Andorra	FP	French Polynesia	IM	Man, Isle Of
AO	Angola	FS	French S & Antarc Lands	MB	Martinique
AV	Anguilla	GB	Gabon	MR	Mauritania
AY	Antarctica	GA	Gambia	MP	Mauritius
AC	Antigua & Barbuda	GZ	Gaza Strip	MF	Mayotte
AR	Argentina	GC	German Dem Rep	MX	Mexico
AT	Ashmore & Cartier Is	BZ	Germany, Berlin	MQ	Midway Is
AS	Australia	GE	Germany, Fed Rep	MN	Monaco
AU	Austria	GH	Ghana	MG	Mongolia
BF	Bahamas	GI	Gibraltar	MH	Montserrat
BA	Bahrain	GO	Glorioso Is	MO	Morocco
FQ	Baker Is	GR	Greece	MZ	Mozambique
BG	Bangladesh	GL	Greenland	WA	Namibia
BB	Barbados	GJ	Grenada	NR	Nauru
BS	Bassas De India	GP	Guadaloupe	BQ	Navassa Is
BE	Belgium	GQ	Guam	NP	Nepal
BH	Belize	GT	Guatemala	NL	Netherlands
BN	Benin	GK	Guernsey	NA	Netherlands Antilles
BD	Bermuda	GV	Guinea	NC	New Calendonias
BT	Bhutan	PU	Guinea-Bissau	NZ	New Zealand
BL	Bolivia	GY	Guyana	NU	Nicaragua
BC	Botswana	HA	Haiti	NG	Niger
BV	Bouvet Is	HM	Heard Is & McDonald	NI	Nigeria
BR	Brazil	HO	Honduras	NE	Niue
IO	Brit Indian Ocean Terr	HK	Hong Kong	NF	Norfolk
VI	Brit Virgin Is	HQ	Howland Is	CQ	Northern Mariana Is
BX	Brunei	HU	Hungary	NO	Norway
BU	Bulgaria	IC	Iceland	MU	Oman
BM	Burma	IN	India	PK	Pakistan
BY	Burundi	ID	Indonesia	LQ	Palmyra Atoll
CM	Cameroon	IR	Iran	PM	Panama
CA	Canada	IZ	Iraq	PP	Papua New Guinea
CV	Cape Verde	IY	Iraq-Saudi Ar Neut Zn	PF	Paracel Is
CJ	Cayman Is	EI	Ireland	PA	Paraguay
CT	Central African Republic	IS	Israel	PE	Peru
CD	Chad	IT	Italy	RP	Philippines
CI	Chile	IV	Ivory Coast	PC	Pitcairn Is
CH	China	JM	Jamaica	PL	Poland
KT	Christmas Is	JN	Jan Mayen	PO	Portugal
IP	Clipperton Is	JA	Japan	RQ	Puerto Rico
CK	Cocos (Keeling) Is	DQ	Jarvis Is	QA	Qatar
CO	Columbia	JE	Jersey	RE	Reunion
CN	Comoros	JQ	Johnston Atoll	RO	Romania
CF	Congo	JO	Jordan	RW	Rwanda
CW	Cook Is	JU	Juan De Nova Is	SC	St Christopher & Nevis
CR	Coral Sea Is	CB	Kampuchea	SH	St Helena
CS	Costa Rica	KE	Kenya	ST	St Lucia
CU	Cuba	KQ	Kingman Reef	SB	St Pierre & Miquelon
CY	Cyprus	KR	Kinibati	VC	St Vincent & Grenadines
CZ	Czechoslovakia	KN	Korea Dem Peop Rep	SM	San Marino
DA	Denmark	KS	Korea Rep	TP	Sao Tome & Principe
DJ	Dyibouti	KU	Kuwait	SA	Saudi Arabia
DO	Dominica	LA	Laos	SG	Senegal
DR	Dominican Republic	LE	Lebanon	SE	Seychelles
EC	Ecuador	LT	Lesotho	SL	Sierra Leone
EG	Egypt	LI	Liberia	SN	Singapore
ES	El Salvador	LY	Libya	BP	Solomon Is
EK	Equatorial Guinea	LS	Liechtenstein	SO	Somalia
ET	Ethiopia	LU	Luxembourg	SP	South Africa
EU	Europa Is	MC	Macau	SP	Spain
FO	Foroe Is	MA	Madagascar	PG	Spratly Is
FA	Falkland Is	MI	Malawi	CE	Sri Lanka



SU Sudan  
 NS Suriname  
 SV Svalbard  
 WZ Swaziland  
 SW Sweden  
 SZ Switzerland  
 SY Syria  
 TW Taiwan  
 TZ Tanzania, Un Rep  
 TH Thailand  
 TO Togo  
 TL Tokelau  
 TN Tonga  
 TD Trinidad And Tobago  
 TE Tromelin Is

NQ Trust Terr Of Pacific Is  
 TS Tunisia  
 TU Turkey  
 TK Turks & Caicos Is  
 TV Tuvalu  
 UG Uganda  
 UR Union Of Soviet Soc Reps  
 TC United Arab Emirates  
 UK United Kingdom  
 US United States Of America  
 UV Upper Volta  
 UY Uruguay  
 NH Vanuatu (New Hebrides)  
 VT Vatican City  
 VE Venezuela

VM Vietnam  
 VQ Virgin Is Of US  
 WQ Wake Is  
 WF Wallis & Fortuna  
 WE West Bank  
 WI Western Sahara  
 WS Western Samoa  
 YS Yemen (Aden)  
 YE Yemen (Sanaa)  
 YO Yugoslavia  
 CC Zaire  
 ZA Zambia  
 ZI Zimbabwe

#### UNITED STATES

01 (AL) Alabama  
 02 (AS) Alaska  
 03 (AZ) Arizona  
 04 (AK) Arkansas  
 05 (CA) California  
 06 (CO) Colorado  
 07 (CT) Connecticut  
 08 (DE) Delaware  
 09 (DC) District Of Columbia  
 10 (FL) Florida  
 11 (GA) Georgia  
 12 (HI) Hawaii  
 13 (ID) Idaho  
 14 (IL) Illinois  
 15 (IN) Indiana  
 16 (IA) Iowa  
 17 (KS) Kansas

18 (KY) Kentucky  
 19 (LA) Louisiana  
 20 (ME) Maine  
 21 (MD) Maryland  
 22 (MA) Massachusetts  
 23 (MI) Michigan  
 24 (MN) Minnesota  
 25 (MS) Mississippi  
 26 (MO) Missouri  
 27 (MT) Montana  
 28 (NB) Nebraska  
 29 (NV) Nevada  
 30 (NH) New Hampshire  
 31 (NJ) New Jersey  
 32 (NM) New Mexico  
 33 (NY) New York  
 34 (NC) North Carolina

35 (ND) North Dakota  
 36 (OH) Ohio  
 37 (OK) Oklahoma  
 38 (OR) Oregon  
 39 (PA) Pennsylvania  
 40 (RI) Rhode Island  
 41 (SC) South Carolina  
 42 (SD) South Dakota  
 43 (TN) Tennessee  
 44 (TX) Texas  
 45 (UT) Utah  
 46 (VT) Vermont  
 47 (VA) Virginia  
 48 (WA) Washington  
 49 (WV) West Virginia  
 50 (WS) Wisconsin  
 51 (WY) Wyoming



**C. PROJECT**

		TYPE	PT
01 Building	02 Structure/Civil	03 Landscape	

**MATERIAL PM**

01 Steel	07 Poured In Place Concrete	13 Wood/Timber
02 Cast Iron	08 Stone	14 Prestressed Concrete
03 Wrought Iron	09 Concrete Block	15 Masonry (unspecified)
04 Aluminum	10 Brick	16 Prestressed Masonry
05 Other Metal	11 Asphalt	
06 Precast Concrete	12 Earth Work	

**STRUCTURAL SYSTEM PS**

01 Footing	09 Girder	17 Tension Membrane
02 Caisson	10 Grid	18 Tension Cable
03 Piling	11 Slab	19 Shell
04 Tubular	12 Frame	20 Folded-Plate
05 Column	13 Arch	21 Truss
06 Pier	14 Vault	22 Space Truss
07 Bearing Wall	15 Dome	23 Continuous
08 Beam	16 Pneumatic	24 Berm/Fill/Grading

**USE PU****STRUCTURE/CIVIL**

101 Special	119 Excavation	137 Retaining Wall
102 Airport, Nav Aid, Fueling	120 Formwork, Shoring	138 Scaffolding
103 Airfield Paving	121 Foundation Structure	139 Seawall, Breakwater
104 Bin, Silo	122 Harbor, Jetty, Pier	140 Sewage/Waste Processing
105 Bridge, Trestle, Viaduct	123 Harbor, Terminal	141 Stack, Chimney
106 Cableway	124 Highway, Road	142 Subaqueous Structure
107 Communications Dish	125 Hoist, Crane	143 Swimming Pool
108 Causeway	126 Hydraulic Structure	144 Tank
109 Cemetery	127 Incinerator	145 Tower, Cooling
110 Containment Vessel	128 Irrigation System	146 Tower, Freestanding
111 Culvert	129 Lighthouse	147 Tower, Guyed
112 Dam	130 Monument	148 Tunnel, Subway
113 Derrick	131 Offshore Structure	149 Wall, Barrier
114 Dike, Levee	132 Park/Playing Field	150 Water Tower
115 Dock, Wharf	133 Parking Area	151 Water Processing
116 Drainage Works	134 Pipeway, Distribution System	152 Waterway
117 Electricity Generation	135 Railway	153 Reservoir
118 Embankment	136 Refinery	

**BUILDINGS**

553 Agriculture, Barn	569 Education, Higher Education	585 Nursing Home
554 Airport Terminal, Hanger	570 Field House, Gymnasium	586 Office Building
555 Airport Freight, Storage	571 Freight Terminal	587 Parking Deck, Structure
556 Apartment	572 Funeral Home	588 Postal Facility
557 Arena	573 Grocery Food Store	589 Public Building
558 Auditorium, Theatre	574 Hospital Special Medical Facility	590 Prison, Correctional
559 Bank	575 Hotel/Motel	591 Recreational Facility
560 Chemical Plant	576 Housing, Duplex	592 Refrigeration Facility
561 Civic BuildingS	577 Housing, Townhouse	593 Religious
562 Commercial, Retail	578 Housing, Detached	594 Restaurant
563 Computer Facility	579 Industrial, Heavy	595 Service Station, Garage
564 Condominium	580 Industrial, Light	596 Shopping Center/Mall
565 Convention Hall	581 Laboratory, Research	597 Stadium
566 Courthouse	582 Library	598 Transportation Terminal
567 Dormitory	583 Museum, Gallery	599 Warehouse
568 Education, Elementary, Secondary	584 Nuclear Facility	



CLASSIFICATION PC

01 New/Original  
02 Renovation/Retrofit  
03 Addition  
04 Demolition

**DIMENSIONS OF PROJECT (Rounded To Nearest Unit)**

				LENGTH	PL
				WIDTH/CROSS SECTION	PW
				HEIGHT	PH
				BAY SPAN	PB
				LONGEST SPAN	PX

**FRACTIONS OF AN INCH**

001 1/16th Inch  
002 1/8th Inch  
003 3/16th Inch  
004 1/4th Inch  
005 5/16th Inch  
006 3/8th Inch  
007 7/16th Inch  
008 1/2th Inch  
009 9/16th Inch  
010 5/8th Inch  
011 11/16th Inch  
012 3/4th Inch  
013 13/16th Inch  
014 7/8th Inch  
015 15/16th Inch

**INCHES**

101-199 (1 - 99) Inches

**FEET**

201-299 (1-99) Feet  
301-399 (1-99) Hundred Feet

**MILES**

401-498 (1-98) Miles  
499 (>99) Miles  
(Please note in abstract any miles over 99)

**DATE**

		YEAR OF DESIGN	COMMISSION	PY
			MONTH/DAY	PP
		YEAR OF CONSTRUCTION	COMMISSION	PR
			MONTH/DAY	PO
		YEAR OF OCCUPANCY/PUBLIC USE	PS	
			MONTH/DAY	PN

**YEAR**

(State actual year)

**SEASONS**

2001 Spring  
2002 Summer  
2003 Fall  
2004 Winter

**DURATION**

3001-3999 Actual Months Duration  
(1-999)  
4001-4999 Actual Years Duration  
(1-999)

**MONTH**

01-12 January - December

**DAY**

01-31 (1-31)

COST PD

0001-0999 (1 - 999) Dollars  
1001-1999 (1 - 999) Thousand Dollars  
2001-2999 (1 - 999) Million Dollars  
3001-3999 (1 - 999) Billion Dollars

PB/PC/PD/PH/PL/PN/PO/PP/PR/PS/PW/PX/PY







**D. INCIDENT/PROBLEM****TYPE IT**

- 01 Property Damage (If None Skip F)  
02 Bodily Injury (If None Skip G)  
03 Management/Delivery Of Services (If None Skip H)

**DATE****YEAR INCIDENT NOTICED IY****MONTH/DAY IM****YEAR INCIDENT NOTIFICATION MADE IR****MONTH/DAY IO****YEAR**

(State actual year)

**SEASONS**

2001 Spring  
2002 Summer  
2003 Fall  
2004 Winter

**DURATION**

3001-3999 Actual Months Duration  
(1-999)

4001-4999 Actual Years Duration  
(1-999)

**MONTH**

01-12 January - December

**DAYS**

01-31 (1-31)



**E. COMPONENT****CSI REFERENCE CODE C**

00010 Pre-Bid Information  
00100 Instructions To Bidders  
00200 Information Available Bidders  
00300 Bid Forms  
00400 Supplements To Bid Forms  
00500 Agreement Forms  
00600 Bonds And Certificates  
00700 General Conditions  
00800 Supplementary Conditions  
00850 Drawings and Schedules  
00900 Addenda And Modifications

**GENERAL REQUIREMENTS**

01010 Summary Of Work  
01020 Allowances  
01025 Measurement And Payment  
01030 Alternates/Alternatives  
01040 Coordination  
01050 Field Engineering  
01060 Regulatory Requirements  
01070 Abbreviations And Symbols  
01080 Identification Systems  
01090 Reference Standards  
01100 Special Project Procedures  
01200 Project Meetings  
01300 Submittals  
01400 Quality Control  
01500 Construction Facilities And Temporary  
01600 Material And Equipment  
01650 Starting Of Systems/Commissioning  
01700 Contract Closeout  
01800 Maintenance

**SITE WORK**

02010 Subsurface Exploration  
02050 Demolition  
02100 Site Preparation  
02140 Dewatering  
02150 Shoring And Underpinning  
02160 Excavation Support Systems  
02170 Cofferdams  
02200 Earthwork  
02300 Tunneling  
02350 Piles And Caissons  
02450 Railroad Work  
02480 Marine Work  
02500 Paving And Surfacing  
02600 Piped Utility Materials  
02660 Water Distribution  
02680 Fuel Distribution  
02700 Sewerage And Drainage  
02760 Restoration Of Underground Pipelines  
02770 Ponds And Reservoirs  
02780 Power And Communications  
02800 Site Improvements  
02900 Landscaping

**CONCRETE**

03100 Concrete Formwork  
03200 Concrete Reinforcement  
03250 Concrete Accessories  
03300 Cast-In-Place Concrete  
03370 Concrete Curing  
03400 Precast Concrete  
03500 Cementitious Decks  
03600 Grout

03700 Concrete Restoration/Cleaning  
03800 Mass Concrete

**MASONRY**

04100 Mortar  
04150 Masonry Accessories  
04200 Unit Masonry  
04400 Stone  
04500 Masonry Restoration And Cleaning  
04550 Refractories  
04600 Corrosion Resistant Masonry

**METALS**

05010 Metal Materials  
05030 Metal Finishes  
05050 Metal Fastening  
05100 Structural Metal Framing  
05200 Steel Joists  
05300 Metal Decking  
05400 Cold-Formed Metal Framing  
05500 Metal Fabrications  
05580 Sheet Metal Fabrications  
05700 Ornamental Metal  
05800 Expansion Control  
05900 Hydraulic Structures

**WOOD AND PLASTICS**

06050 Fasteners And Adhesives  
06100 Rough Carpentry  
06130 Heavy Timber Construction  
06150 Wood-Metal Systems  
06170 Prefabricated Structural Wood  
06200 Finish Carpentry  
06300 Wood Treatment  
06400 Architectural Woodwork  
06500 Prefabricated Structural Plastics  
06600 Plastic Fabrications

**THERMAL MOISTURE PROTECTION**

07100 Waterproofing  
07150 Dampproofing  
07190 Vapor And Air Retarders  
07200 Insulation  
07250 Fireproofing  
07300 Shingles And Roofing Tiles  
07400 Preformed Roofing And Cladding/Siding  
07500 Membrane Roofing  
07570 Traffic Topping  
07600 Flashing And Sheet Metal  
07700 Roof Specialties And Accessories  
07800 Skylights  
07900 Joint Sealers

**DOORS AND WINDOWS**

08100 Metal doors And Frames  
08200 Wood And Plastic Doors  
08250 Door Opening Assemblies  
08300 Special Doors  
08400 Entrances And Storefronts  
08500 Metal Windows  
08600 Wood And Plastic Windows  
08650 Special Windows

08700 Hardware  
08800 Glazing  
08900 Glazed Curtain Walls

**FINISHES**

09100 Metal Support Systems  
09200 Lath And Plaster  
09230 Aggregate Coatings  
09250 Gypsum Board  
09300 Tile  
09400 Terrazzo  
09500 Acoustical Treatment  
09540 Special Surfaces  
09550 Wood Flooring  
09600 Stone Flooring  
09630 Unit Masonry Flooring  
09650 Resilient Flooring  
09680 Carpet  
09700 Special Flooring  
09780 Floor Treatment  
09800 Special Coatings  
09900 Painting  
09950 Wall Coverings

**SPECIALTIES**

10100 Chalkboards And Tackboards  
10150 Compartment And Cubicals  
10200 Louvers And Vents  
10240 Grilles And Screens  
10250 Service Wall Systems  
10260 Wall And Corner Guards  
10270 Access Flooring  
10280 Specialty Modules  
10290 Pest Control  
10300 Fireplaces And Stoves  
10340 Prefabricated Exterior Specialties  
10350 Flagpoles  
10400 Identifying Devices  
10450 Pedestrian Control Devices  
10500 Lockers  
10520 Fire Protection Specialties  
10530 Protective Covers  
10550 Postal Specialties  
10600 Partitions  
10650 Operable Partitions  
10670 Storage Shelving  
10700 Exterior Sun Control Devices  
10750 Telephone Specialties  
10800 Toilet And Bath Accessories  
10880 Scales  
10900 Wardrobe/Closet Specialties

**EQUIPMENT**

11010 Maintenance Equipment  
11020 Security And Vault Equipment  
11030 Teller And Service Equipment  
11040 Ecclesiastical Equipment  
11050 Library Equipment  
11060 Theater And Stage Equipment  
11070 Instrumental Equipment  
11080 Registration Equipment  
11090 Checkroom Equipment  
11100 Mercantile Equipment  
11110 Commercial Laundry And Dry Cleaning  
11120 Vending Equipment  
11130 Audio-Visual Equipment  
11140 Service Station Equipment



11150 Parking Control Equipment  
 11160 Loading dock Equipment  
 11170 Solid Waste Handling Equipment  
 11190 Detention Equipment  
 11200 Water Supply And Treatment Equipment  
 11280 Hydraulic Gates And Valves  
 11300 Fluid Waste Treatment Equipment  
 11400 Food Service Equipment  
 11450 Residential Equipment  
 11460 Unit Kitchens  
 11470 Darkroom Equipment  
 11480 Athletic, Recreational And Therapeutic Equipment  
 11500 Industrial/Process Equipment  
 11600 Laboratory Equipment  
 11650 Planetarium Equipment  
 11660 Observatory Equipment  
 11700 Medical Equipment  
 11780 Mortuary Equipment  
 11850 Navigation Equipment

#### FURNISHINGS

12050 Fabrics  
 12100 Artwork  
 12300 Manufactured Casework  
 12500 Window Treatment  
 12600 Furniture And Accessories  
 12670 Rugs And Mats  
 12700 Multiple Seating  
 12800 Interior Plants And Planters

#### SPECIAL CONSTRUCTION

13010 Air supported Structures  
 13020 Integrated Assemblies

13030 Special Purpose Rooms  
 13080 Sound, Vibration, And Seismic Control  
 13090 Radiation Protection  
 13100 Nuclear Reactors  
 13120 Pre-Engineered Structures  
 13150 Pools  
 13160 Ice Rinks  
 13170 Kennels And Animal Shelters  
 13180 Site Constructed Incinerators  
 13200 Liquid And Gas Storage Tanks  
 13220 Filter Underdrains And Media  
 13230 Digestion Tank Covers And Appurtenances  
 13240 Oxygenation Systems  
 13260 Sludge Conditioning Systems  
 13300 Utility Control Systems  
 13400 Industrial And Process Control Systems  
 13500 Recording Instrumentation  
 13550 Transportation Control Instrumentation  
 13600 Solar Energy Systems  
 13700 Wind Energy Systems  
 13800 Building Automation Systems  
 13900 Fire Suppression And Supervisory Systems

#### CONVEYING SYSTEMS

14100 Dumbwaiters  
 14200 Elevators  
 14300 Moving Stairs And Walks  
 14400 Lifts  
 14500 Material Handling Systems  
 14600 Hoists And Cranes

14700 Turntables  
 14800 Scaffolding  
 14900 Transportation Systems

#### MECHANICAL

15050 Basic Mechanical Materials And Methods  
 15250 Mechanical Insulation  
 15300 Fire Protection  
 15400 Plumbing  
 15500 Heating, Ventilating, And Air Conditioning (HVAC)  
 15550 Heat Generation  
 15650 Refrigeration  
 15750 Heat Transfer  
 15850 Air Handling  
 15880 Air Distribution  
 15950 Controls  
 15990 Testing, Adjusting, And Balancing

#### ELECTRICAL

16050 Basic Mechanical Materials And Methods  
 16200 Power Generation  
 16300 High Voltage Distribution (Above 600-Volt)  
 16400 Service And Distribution (600-Volt And Below)  
 16500 Lighting  
 16600 Special Systems  
 16700 Communications  
 16850 Electric Resistance Heating  
 16900 Controls  
 16950 Testing

### COMPONENT/ELEMENT CE

110 SITE, SUBSTRUCTURE  
 111 Excavation, Grading, Compaction  
 112 Sheet piling  
 113 Piles, Caissons  
 114 Drainage  
 115 Bedding  
 116 Tunnel Lining  
 117 Retaining Wall  
 118 Dam  
 119 Cofferdam  
 220 SUBSTRUCTURE, FOUNDATION  
 221 Footings, Line  
 222 Footings, Mat  
 223 Footings, Column  
 224 Pier  
 225 Wall  
 226 Buttress  
 227 Pile Cap  
 228 Abutment  
 229 Slab  
 330 STRUCTURE  
 331 Vertical System  
 332 Horizontal System  
 333 Continuous Structure  
 334 Anchorage  
 335 Connection  
 336 Joint  
 337 Arch, Shell  
 338 Suspension  
 339 Membrane  
 440 EXTERIOR, ENVELOPE

441 Window  
 442 Door  
 443 Roof  
 444 Wall Panel  
 445 Insulation  
 446 Waterproofing  
 447 Flashing  
 448 Caulk, Sealant  
 449 Paint  
 450 Horizontal Circulation  
 451 Vertical Circulation  
 550 INTERIOR  
 551 Wall  
 552 Floor  
 553 Ceiling  
 554 Horizontal Circulation  
 555 Vertical Circulation  
 556 Core  
 557 Spaces  
 558 Surfaces  
 559 Contents  
 660 TEMPORARY CONSTRUCTION  
 661 Bracing  
 662 Shoring  
 663 Formwork  
 664 Scaffolding  
 665 Equipment  
 666 Fireplace  
 667  
 668  
 669

770 MECHANICAL/ELECTRICAL SYSTEMS  
 771 Cooling  
 772 Heating  
 773 Ventilation  
 774 Plumbing  
 775 Lighting  
 776 Transport  
 777 Hazard Detection, Protection  
 778 Emergency Power, Supply  
 779 Power  
 880 PAVING, LANDSCAPE  
 881 Walkway  
 882 Roadway  
 883 Runway  
 884 Bridge Deck  
 885 Channel Lining  
 886 Trenching  
 887 Drainage  
 888 Fence/Wall  
 889 Plant Material (Natural)  
 990 SPECIAL CONSTRUCTION  
 991 Marine Installation  
 992 Oil, Gas, Other Installation  
 993 Tower, Stack, Chimney  
 994 Water Containment  
 995 Toxic Materials Handling  
 996 Low Voltage Electricity  
 997 High Voltage Electricity  
 998 Sewage Treatment  
 999 Crane, Boom



COMPONENT MATERIAL CM		
SUB-SYSTEM MATERIAL CS		
01 Steel, Steel Components	09 Paint	17 Wood
02 Other Metals, Alloys	10 Coatings	18 Interior Coverings
03 Cement, Mortar	11 Sealants	19 Finishes
04 Masonry	12 Plastic	20 Synthetics
05 Concrete, Mineral Aggregates	13 Rubber	21 Equipment
06 Glass	14 Membrane	22 Fiber/Insulative Material
07 Tile, Ceramics	15 Building Stone	23 Gravel, Crushed Rock
08 Bituminous, Asphalt	16 Earthworks	

DIMENSIONS OF COMPONENT (Rounded To Nearest Unit)		
LENGTH CL		
WIDTH/CROSS SECTION CW		
HEIGHT CH		
BAY SPAN CB		

#### FRACTIONS OF AN INCH

001 1/16th Inch  
002 1/8th Inch  
003 3/16th Inch  
004 1/4th Inch  
005 5/16th Inch  
006 3/8th Inch  
007 7/16th Inch  
008 1/2th Inch  
009 9/16th Inch  
010 5/8th Inch  
011 11/16th Inch  
012 3/4th Inch  
013 13/16th Inch  
014 7/8th Inch  
015 15/16th Inch

#### INCHES

101-199 (1 - 99) Inches

#### FEET

201-299 (1-99) Feet  
301-399 (1-99) Hundred Feet

#### MILES

401-498 (1-98) Miles  
499 (>99) Miles  
(Please note in abstract any miles over 99)

CB/CH/CL/CM/CS/CW







**F. PROPERTY DAMAGE/EFFECT****CATALYST EY**

01 Loads  
02 Cold  
03 Heat  
04 Wind  
05 Water

06 Condensation  
07 Vibration  
08 Impact  
09 Equipment  
10 Soils

11 Fire  
12 Maintenance  
13 Earthquake  
14 Corrosion  
15 Flammables/Liquid, Gas

**RESULT/EFFECT ER**

01 Cosmetic/Aesthetic  
02 Cracks  
03 Moisture Penetration  
04 Infiltration/Thermal  
05 Mechanical Malfunction  
06 Electrical Malfunction

07 Acoustical Impairment  
08 Plumbing Malfunction  
09 Environmental Dysfunction  
10 Deformation  
11 Movement/Deflection  
12 Partial Collapse

13 Significant Collapse/Destruction  
14 Interior/Spatial Dysfunction  
15 Fire/Explosion  
16 Falling Objects  
17 Inundation/Liquid, Water

**COST TO REMEDY ED**

0001-0999 (1 - 999) Dollars  
1001-1999 (1 - 999) Thousand Dollars  
2001-2999 (1 - 999) Million Dollars  
3001-3999 (1 - 999) Billion Dollars



**G. BODILY INJURY/DEATHS****PHASE OF ACCIDENT BA**

01 Construction

02 Occupancy

03 Demolition

**LOCATION OF ACCIDENT BL**

01 Roof

02 Floor

03 Hallway

04 People Mover

05 Bridgeway

06 Escalator

07 Elevator

08 Stair

09 Ramp

10 Ladder

11 Window

12 Door

13 Pool

14 Special Room

15 Furniture

16 Fixture

17 Tool

18 Machines

19 Electrical Apparatus

20 Mechanical Apparatus

21 Plumbing Apparatus

22 Platform

23 Sidewalk

24 Parking Lot

25 Roadway

26 Scaffolding

27 Tunnel

28 Trench

29 Construction Equipment

30 Maintenance Equipment

**TYPE OF PERSON(S) BP**

01 Construction Worker

02 Building Worker

03 Public/User

**CATALYST BC**

01 Oily

02 Wet

03 Slippery

04 Fixed Object

05 Rough

06 Broken

07 Uneven

08 Openings

09 Debris

10 Weakness

11 Insecurity

12 Pollutants

13 Safety Precautions

14 Hot

15 Cold

16 Wind/Lateral Pressure

**RESULT BR**

01 Fall

02 Burial

03 Electrocution

04 Trip

05 Collision

06 Exposure

07 Explosion

08 Falling Object/No Collapse

09 Collapse Including Falling Objects

10 Fire

**DEATHS BD****INJURIES BI**

0001-0999 (1-9,999) Persons

(Please note in abstract all deaths and/or injuries over 10,000)

BA/BC/BD/BI/BL/BP/BR



## H. MANAGEMENT/DELIVERY OF SERVICES

DELAY MD

01-98 (1-98) Months  
99 (>99) Months

(Please note in abstract all delays over 99 Months)

OVERRUN MO  
EXTRAS ME

0001-0999 (1 - 999) Dollars  
1001-1999 (1 - 999) Thousand Dollars  
2001-2999 (1 - 999) Million Dollars  
3001-3999 (1 - 999) Billion Dollars

STAGE MS

01 Permits, Liens  
02 Design  
03 Equipment

04 Site Preparation  
05 Construction  
06 Punch List

07 Occupancy

CATALYST/PERSON MC

01 Surveyor  
02 Designer  
03 Contractor

04 SubContractor  
05 Owner  
06 Manufacturer

07 Labor (Strike)  
08 Material Supply, Distrib  
(Shortage)

MC/MD/ME/MO/MS



# **I. PARTIES INVOLVED**

## **ALLEGED DEFENDANT/RESPONSIBLE PARTY FD CLAIMANT/PLAINTIFF/CONCERNED PARTY FP**

01 Architect	10 Electrical	19 Insurance Company
02 Landscape Architect	11 Geological	20 Owner
03 Interior Designer	12 Contractor	21 Unrelated Individual
04 Planner/Urban Designer	13 SubContractor	22 Developer
05 Architect/Engineer	14 Construction Worker	23 Federal Government
06 Engineer/Architect	15 Building Worker/Employee	24 State Government
07 Structural	16 Fabricator/Manufacturer	25 Local Government
08 Civil	17 Distributor/Supplier	
09 Mechanical	18 Surveyor	

## **SIZE OF RESPONSIBLE FIRM/DEFENDANT FS**

0001-0999 (1 - 999) Persons  
1001-1999 (1 - 999) Thousand Persons

## **OWNER OF PROJECT FO**

01 Federal Government	05 Profit Organization	09 Joint Venture
02 State Government	06 Speculative Developer	10 Individual
03 Local Government	07 Design/Build	11 Foreign Government
04 Non-Profit Organization	08 Partnership	

FD/FO/FP/FS





## J. SERVICES

### TYPE OF SERVICES RELATING TO PROBLEM SP

01 Architectural	05 Electrical	09 Fabrication
02 Structural	06 Geological	10 Distribution/Supply
03 Civil	07 Surveying	11 Landscape
04 Mechanical	08 Construction	

### TYPE OF DESIGN CONTRACT SC

01 ALA/NSPE	04 State	07 Oral
02 ACEC	05 Military	08 Local Government
03 Federal	06 Other Written	

### TYPE OF SERVICES RELATING TO CONTRACT SR

01 Survey	06 Shop Drawings	11 Fabrication
02 Bid/Estimates	07 Design Drawings	12 Distribution
03 Study/Report/Testing	08 Construction Documents	13 Construction
04 Basic/Full Services	09 Construction Management	14 Maintenance
05 Plans, Specifications	10 Observation/Inspection	

### TYPE OF SELECTION PROCESS SS

01 Lump Sum, Competitive	04 Unit Price, Competitive Bid	07 Mandatory Low Bid
02 Selected Bidders	05 Unit Price, Lump Sum	
03 Lump Sum, Negotiated	06 Cost Plus Fixed Fee	

SC/SP/SR/SS



**K. ALLEGATIONS****TYPE OF SUIT/CLAIM/INTENT TO SUE AT**

01 Single  
02 Multiple, Primary Party Named

03 Multiple, Secondary/Many Parties  
Named

04 Counter  
05 Counter & Multiple

**STATUS OF CHARGES AC**

01 Notice Of Problem  
02 Investigation  
03 Informal Claim  
04 Claim  
05 Negotiation  
06 Litigation, In Suit

07 In Trial  
08 Settlement  
09 In Arbitration  
10 Arbitration/Decision  
11 Civil Suit Verdict  
12 Criminal Verdict

13 State Board Review  
14 Appeal Civil Suit Verdict  
15 Appeal Criminal Verdict  
16 In Mediation  
17 Mediation/Decision

**AMOUNT PLAINTIFF SUED FOR AS  
AMOUNT OF SETTLEMENT AD**

0001-0999 (1-999) Dollars  
1001-1999 (1-999) Thousand Dollars  
2001-2999 (1-999) Million Dollars  
3001-3999 (1-999) Billion Dollars

**ACTIVITY CAUSING ERROR AA**

01 Bidding  
02 Planning, Service  
03 Design  
04 Specifications  
05 Field Order/No Cost Change  
06 Change Order

07 Fabrication  
08 Transportation  
09 Construction  
10 Inspection/Observation  
11 Repair  
12 Occupancy

13 Maintenance  
14 Testing  
15 Nonpayment  
16 Installation (Equipment, Etc.)  
17 Survey (Land)  
18 Demolition

**REASON FOR FAILURE AR**

01 Poor Assumptions  
02 Survey Error  
03 Design Error  
04 Design Omission  
05 Practice Error  
06 Improper Specifications  
07 Mismanagement/Rush  
08 Poor Scheduling

09 Drafting/Copy Error  
10 Communications Error  
11 Poor Quality Fabrication  
12 Poor Quality Material  
13 Poor Quality Construction  
14 Poor Quality Workmanship  
15 Poor Observation/Inspection  
16 Poor Maintenance

17 Improper Codes/Standards  
18 Negligent Practice  
19 Criminal Negligence  
20 Intentional Conduct  
21 Natural Causes  
22 Normal Aging Of Materials  
23 Misuse Of Area  
24 Vandalism

AA/AC/AD/AR/AS/AT



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c.1 Constructability im-  
provement.

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M8384 Morro  
c.1 Constructability im-  
provement.

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